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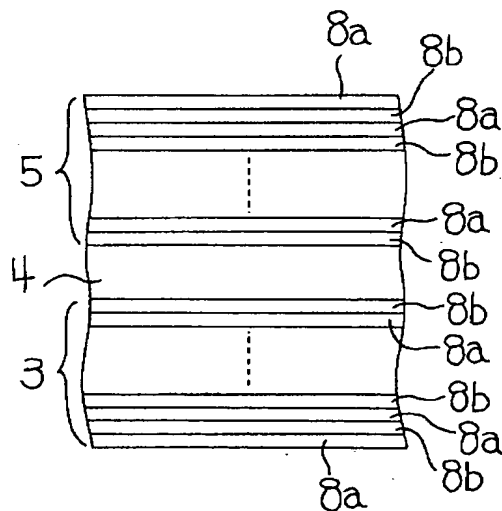
(54)【発明の名称】　イメージングデバイス

(57)【要約】

【課題】　広い波長範囲に渡ってより大きな磁気光学効果を得ることができ、画像コントラストを大幅に向上させ得るイメージングデバイスを提供する。

【解決手段】　膜厚を連続的に増減させた透明磁性層4と、屈折率の異なる2種類の多数の誘電体膜8a，8bが交互に積層されて透明磁性層4を挟む一対の誘電体多層膜3，5とを備えることで、透明磁性層4を一対の誘電体多層膜3，5で挟む構造により基本的に磁気光学効果を増大させ得る上に、増大効果が発揮される波長を規定する透明磁性層4の膜厚を連続的に増減させたことで、適用波長範囲を広げることができる。

１

【特許請求の範囲】

【請求項１】　膜厚を連続的に増減させた透明磁性層と、

屈折率の異なる２種類の多数の誘電体膜が交互に積層されて前記透明磁性層を挟む一対の誘電体多層膜と、を備えるイメージングデバイス。

【請求項２】　膜厚を連続的に増減させた透明磁性層と、屈折率の異なる２種類の多数の誘電体膜が交互に積層されて前記透明磁性層を挟む一対の誘電体多層膜とよりなる構造体を複数層積層した構造を備えるイメージングデバイス。

【請求項３】　一対の誘電体多層膜は、材料、積層数、膜厚が全く同一で透明磁性層に対して対称である請求項１又は２記載のイメージングデバイス。

【請求項４】　透明磁性層は、平均膜厚が１００～４００ｎｍである請求項１，２又は３記載のイメージングデバイス。

【請求項５】　最外層の誘電体多層膜の外面に、互いの偏光軸を回転させてなる一対の偏光子を備える請求項１，２，３又は４記載のイメージングデバイス。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、画像を形成するためのデバイスであって、その可視化によりディスプレイ等への応用も可能なイメージングデバイスに関する。

【０００２】

【従来の技術】従来より、磁気光学効果（ファラデー効果ないしは磁気光学カー効果）を示す磁性体は、例えば、光磁気ディスクに利用されて情報の書込み・再生が可能とされている。この他、磁気光学効果を示す透明磁性体を用いこの透明磁性体に対して磁気ヘッドを用いて画像の書込みを行って画像を形成するためのイメージデバイス等への応用が検討されている。また、光を照射させることでファラデー回転の有無により画像を可視化表示させるディスプレイへの応用も検討されている。

【０００３】ここに、磁性体と空隙とが交互に一次元的に配列された周期構造を持つ不連続磁性媒体や、乱れた積層構造を持つ多層薄膜の磁気光学効果に関して、その磁気光学効果が単なる連続媒体に比して増大する点に関する解析及びその結果が、①諌本、山本、井上、藤井：電子情報通信学会　信学技報　ＭＲ９４-８７，ＣＰＭ９４-１１２(１９９５-０２) ｐ１５～２２の「不連続磁性媒体の磁気光学ファラデー効果の理論解析」、②諌本、山本、井上、藤井：電気学会マグネティック研究会資料Ｖｏｌ.ＭＡＧ-９５-１３２，Ｎｏ.１３１-１４１ ｐ９～１８ (１９９５) の「準ランダム一次元アレー構造をもつ不連続磁性媒体の磁気光学効果」、③井上、藤井：日本応用磁気学会誌２１，１８７-１９２(１９９７)の「乱れた積層構造をもつ多層薄膜の光局在化による磁気光学ファラデー効果の巨大エンハンスメント」等の文献により報告されている。

２

【０００４】また、透明磁性体を一対の誘電体多層膜で挟んで磁気光学効果を増大させるようにした磁気光学素子に関する提案も本出願人によってなされている。

【０００５】

【発明が解決しようとする課題】ところが、透明磁性体を一対の誘電体多層膜で挟んで磁気光学効果を増大させる上記既提案例では、特定波長ではなく、可視光全般の磁気光学効果の増大を意図したものであるが、その増大効果はせいぜい２倍程度に留まるものである。

【０００６】また、上記①～③の文献等にも示されているように、特定波長の磁気光学効果を増大させるには、透明磁性膜の膜厚及び誘電体多層膜各層の膜厚を厳密に制御することによって選択することが可能である。しかし、この結果必然的に増大される波長範囲はシャープであり、狭いものとなっている。従って、単一波長のレーザ光の場合には有効といえるが、例えば、コントラストの大きな画像を得る場合のように、より広い波長範囲の光に適用することが望まれる目的には不向きである。

【０００７】そこで、本発明は、広い波長範囲に渡ってより大きな磁気光学効果を得ることができ、画像コントラストを大幅に向上させ得るイメージングデバイスを提供することを目的とする。

【０００８】

【課題を解決するための手段】請求項１記載の発明は、膜厚を連続的に増減させた透明磁性層と、屈折率の異なる２種類の多数の誘電体膜が交互に積層されて前記透明磁性層を挟む一対の誘電体多層膜とを備える。従って、基本的に透明磁性層を一対の誘電体多層膜で挟む構造により磁気光学効果を増大させ得るが、増大効果が発揮される波長を規定する透明磁性層の膜厚が連続的に増減しているので、適用波長範囲を広げることができる。

【０００９】請求項２記載の発明は、膜厚を連続的に増減させた透明磁性層と、屈折率の異なる２種類の多数の誘電体膜が交互に積層されて前記透明磁性層を挟む一対の誘電体多層膜とよりなる構造体を複数層積層した構造を備える。従って、基本的に請求項１記載の発明の場合と同様に適用波長範囲を広げ得るが、さらに、同一の構造体を複数層積層してなるので、磁気光学効果を一層増大させることができ、画像コントラストも大幅に向上させることができる。

【００１０】請求項３記載の発明は、請求項１又は２記載のイメージングデバイスにおける一対の誘電体多層膜は、材料、積層数、膜厚が全く同一で透明磁性層に対して対称である。従って、一対の誘電体多層膜が同一構造からなるので、磁気光学効果の増大が安定して得られる。

【００１１】請求項４記載の発明は、請求項１，２又は３記載のイメージングデバイスにおける透明磁性層は、平均膜厚が１００～４００ｎｍである。従って、画像を形成するためのイメージングデバイスとして標準的な波

長域の光を用いることができる。

【００１２】請求項５記載の発明は、請求項１，２，３又は４記載のイメージングデバイスに加えて、最外層の誘電体多層膜の外面に、互いの偏光軸を回転させてなる一対の偏光子を備える。従って、イメージングデバイスに形成された画像をコントラストの高い状態で可視化することができ、ディスプレイ等に応用し得る。

【００１３】

【発明の実施の形態】本発明の一実施の形態を図面に基づいて説明する。本実施の形態のイメージングデバイス１は、透明基板２上に誘電体多層膜３、透明磁性層４、誘電体多層膜５を順次積層し、これらの積層構造体を一対の偏光子６，７で挟んだサンドイッチ構造として形成されている。

【００１４】ここに、透明磁性層４の膜厚は、基本的にはファラデー回転角を増大させたい波長λに対してλ／２に設定されるが、本実施の形態では、この波長λより少し長い波長や短い長であっても大きなファラデー回転角が得られるようにこの透明磁性層４の膜厚が連続的に増減変化するように形成されている。変化させる範囲は、ファラデー回転角を増大させたい波長λに対してλ／±３０％、好ましくは、λ／±２０％以内がよい。例えば、λ＝５００ｎｍの波長光のファラデー回転角を増大させたい場合であれば、透明磁性層４の膜厚が（２５０±２５）ｎｍとなるように作製すればよい。透明磁性層４がＰＶＤ法による薄膜の場合であれば、このような膜厚の連続的傾斜（増減変化）は、透明基板２の傾斜や、透明基板２と蒸気源との間に邪魔板を介在させる等の手法により容易に実現できる。透明磁性層４の膜厚の変化は、連続的であればよく、必ずしも単調増減に限らず、増減を繰返すパターンであってもよい。

【００１５】ここに、透明磁性層４の平均膜厚は上記のように可視光波長λの１／２に設定されるので、ファラデー回転角が絶対的な大きさにおいて不十分な場合を生ずる。このような場合には、透明基板２上に、誘電体多層膜３／透明磁性層４／誘電体多層膜５よりなる構造体を、全く同じ構造として複数層積層させた構造とすれば、十分なファラデー回転角が得られる。誘電体多層膜３／透明磁性層４／誘電体多層膜５よりなる構造体を２回繰り返せば（積層すれば）、約２倍のファラデー回転角が得られる。

【００１６】このような透明磁性層４の材料としては従来一般に用いられている磁気光学効果を示す透明磁性材料でよいが、ファラデー効果が大きくて透明性の大きい、所謂、性能指数の大きい磁性材料が好ましい。例えば、５０ｎｍ以下の粒子径を有するＦｅ，Ｃｏ，Ｎｉ等の強磁性金属の超微粒子膜を用い得る。この場合の金属超微粒子以外の膜組成には酸素、炭素等が含まれる。Ｆ

ｅ，Ｃｏ，Ｎｉ等の強磁性金属は大きな磁気光学効果を示すが、光の吸収も大きいためにそのままの薄膜では用いられなかったが、超微粒子膜とすると大きな性能指数を有する。また、粒子径の制御により適当な保磁力を得ることができる。他に、希土類鉄ガーネットやコバルトフェライト、Ｂａフェライト等の酸化物、$FeBO_3$，FeF_3，$YFeO_3$，$NdFeO_3$等の複屈折性の大きな材料、$MnBi$，$MnCuBi$，$PtCo$等の超微粒子も利用可能である。磁気光学効果は、光の進行方向とスピンの方向とが平行な場合に最も大きな効果が得られるので、これらの透明磁性材料は膜面に垂直な方向に磁気異方性を有する膜として形成するのが好ましい。このような透明磁性層４の作製には、一般的なスパッタリング法、真空蒸着法、ＭＢＥ等のＰＶＤ法、ＣＶＤ法、メッキ法等を用い得る。

【００１７】何れにしても、これらの磁性材料のファラデー効果には材料固有の波長依存性がある。そこで、上述したような磁性材料を用いる場合にはその波長依存性を考慮して透明磁性層４の膜厚（平均膜厚）を決定しなければならない。図３は一例として希土類鉄ガーネットの場合のファラデー回転角の波長依存性を示す。しかも、分光透過率の測定から、４５０ｎｍ付近のファラデー回転角のピークは、吸収のため、画像濃度への寄与は少ないことが判っている。従って、本実施の形態において誘電体多層膜３，５でファラデー回転角を増大させる波長は５２０ｎｍ程度とするのが好ましい。

【００１８】誘電体多層膜３，５は、その材料、積層数、膜厚等が全く同一に形成されたもので、各々、屈折率が高低異なる２種類の誘電体膜８ａ，８ｂを１ペアとして多数積層させてなる。ペア数は特に制限がないが、３～２０ペア程度とするのが性能上、コスト上好ましい。また、透明磁性層４に直接接する膜の種類としては、誘電体多層膜３，５で同じ誘電体膜８ａ又は８ｂを用いるので、図２に示すように、積層順序は逆となる。即ち、誘電体多層膜３，５は透明磁性層４に対して対称構造とされている。ここに、誘電体膜８ａ，８ｂの材料は、例えば、誘電体膜８ａとしてはSiO_2，誘電体膜８ｂとしてはTa_2O_5等を用い得るが、これらを含めて表１に示すような各種材料を用い得る。これらの材料中から適宜選択してもよく、或は、これ以外の材料、例えば有機物であっても構わない。誘電体膜８ａ，８ｂの各膜厚は５０～２００ｎｍ程度が好ましい。特定波長λの磁気光学効果の増大を目的とする場合であれば、誘電体膜８ａ，８ｂの膜厚はλ／４ｎ（ｎは波長λにおける誘電体の屈折率）とする。

【００１９】

【表１】

5　　　　　　　　　　　　　　　　　　　　　　　　　　6

	物　　質	屈折率(波長[nm])	透明波長域
n＜1.5	calcium　fluoride(CaF₂)	1.23〜1.26(546)	150nm〜12μm
	sodium　fluoride(NaF)	1.34　　(550)	250nm〜14μm
	cryolite(Na₃AlF₆)	1.35　　(550)	＜200nm〜14μm
	lithium　fluoride(LiF)	1.36〜1.37(546)	110nm〜7μm
	magnesium　fluoride(MgF₂)	1.38　　(550)	210nm〜10μm
	silicon　dioxide(SiO₂)	1.46　　(500)	＜200nm〜8μm
1.5＜n＜2	lanthanum　fluoride(LaF₃)	1.59　　(550)	220nm〜＞2μm
	neodymium　fluoride(NdF₃)	1.6　　(550)	220nm〜＞2μm
	aluminum　oxide(Al₂O₃)	1.62　　(600)	
	cerium　fluoride(CeF₃)	1.63　　(550)	300nm〜＞5μm
	lead　fluoride(PbF₂)	1.75　　(550)	240nm〜＞20μm
	magnesium　oxide(MgO)	1.75　　(500)	
	thorium　oxide(ThO₂)	1.8　　(550)	250nm〜＞2μm
	tin　oxide(SnO₂)	1.9　　(550)	
	lanthanum　oxide(La₂O₃)	1.95　　(550)	350nm〜＞2μm
	silicon　monoxide(SiO)	1.7〜2.0　(550)	500nm〜8μm
2＜n＜3	indium　oxide(In₂O₃)	2.0　　(500)	
	neodymium　oxide(Nd₂O₃)	2.0　　(550)	400nm〜＞2μm
	antimony　trioxide(Sb₂O₃)	2.04　　(546)	300nm〜＞1μm
	zirconium　oxide(ZrO₂)	2.1　　(550)	
	cerium　dioxide(CeO₂)	2.2　　(550)	400nm〜10μm
	titanium　dioxide(TiO₂)	2.2〜2.7(550)	350nm〜12μm
	zinc　sulfide(ZnS)	2.35　　(550)	380nm〜25μm
	bismuth　oxide(Bi₂O₃)	2.45　　(550)	
	zinc　selenide(ZnSe)	2.58　　(633)	600nm〜＞15μm
	cadmium　sulfide(CdS)	2.6　　(600)	600nm〜7μm
3＜n	antimony-sulfide(Sb₂S₃)	3.0　　(589)	500nm〜10μm
	cadmium　telluride(CdTe)	3.05　　(IR)	
	silicon(Si)	3.5	1.1nm〜10μm
	germanium(Ge)	4.0	1.7nm〜100μm
	tellurium(Te)	4.9　　(6μm)	3.4nm〜20μm
	lead　telluride(PbTe)	5.5	3.4nm〜30μm

【００２０】透明基板２としては、石英ガラス、サファイア、結晶化透明ガラス、パイレックスガラス、Ａl₂O₃、MgO、BeO、ZrO₂、Y₂O₃、ThO₂・CaO、GGG（ガドリニウム・ガリウム・ガーネット）等の無機透明材料や、MMA、PMMA、ポリカーボネート、ポリプロピレン、アクリル系樹脂、スチレン系樹脂、ＡＢＳ樹脂、ポリアリレート、ポリサルフォン、ポリエーテルサルフォン、エポキシ樹脂、ポリ‐４‐メチルペンテン‐１、フッ素化ポリイミド、フッ素樹脂、フェノキシ樹脂、ポリオレフィン系樹脂、ナイロン樹脂等の透明プラスチックフィルムが用いられる。透明プラスチックフィルムを用いると、軽い、曲げやすい等の利点があるので使いやすい。

【００２１】偏光子６，７を用いるのは、誘電体多層膜

5／透明磁性層４／誘電体多層膜３／透明基板２なる構成において、透明磁性層４の磁化された部位で得られる大きなファラデー回転角を、画像として可視化するためである。即ち、透明磁性層４の磁化された部位に対応して大きなファラデー回転角が得られるのに対して、磁化されていない部位では光の偏光面が回転しないので、一対の偏光子６，７の偏光軸（吸収又は透過軸）を、偏光面回転部位と非回転部位とでコントラストが最も大きくなるように回転させておけば、偏光面回転部位では透過光のため白く、非回転部位では両偏光子６，７を通過できないため黒く見えることになり、画像が可視化される。

【００２２】このような偏光子６，７としては、各種の市販の偏光フィルム、ビームスプリッタを用いた高透過

率偏光子等を利用し得る。偏光フィルムは大別すると多ハロゲン偏光フィルム、染料偏光フィルム、金属偏光フィルム等がある。多ハロゲン偏光フィルムは２色性物質にヨウ素を用いているために可視光領域全般についてフラットな特性を有するが、反面、湿度、高温等に弱いという欠点がある。染料偏光フィルムは偏光性能がヨウ素よりも劣るものの、熱、光、湿度に対して耐性が大きいという特長を有している。何れにしても、偏光子６，７の表面（露出面）はきずが付きやすいので、実際には保護膜を設けるのが好ましい。

【００２３】また、偏光子６，７としては、以下に例示するような各種の偏光子も利用できる。例えば、特開平１－９３７０２号公報に示されるように、強磁性体微粒子からなる多数の棒状素子を含む偏光層を基板表面に一定方向に配列して固着形成することにより、製造が容易で光学的特性に優れた偏光板がある。また、東京農工大学　佐藤勝昭教授著「現代人の物理１－光と磁気」（１９８８年出版）p103 に記載されているワイヤグリッド偏光子がある。これは、２．５μmより長波長の光に対する偏光子であって、透明基板（臭化銀、ポリエチレン等）に微小な間隔で金やアルミニウムの線を引いたものである。線の間隔をｄ、波長をλとすると、λ≫ｄなる波長光に対して透過光は線に垂直な振動面を持つほぼ完全な直線偏光になることを利用したものである。中赤外用（２．５～２５μm）としては、臭化銀基板にｄ＝０．３μm間隔で金線を引いたものが、遠赤外用（１６～１００μm）としては、ポリエチレン板にｄ＝０．７μmでアルミニウム線を引いたものが用いられる。また、コーニング社製のポーラコア（商品名）がある。これは、長く延伸させた金属銀をガラス自身の中に一方向に配列させることにより、偏光特性を持たせたガラスであり、従来の有機物偏光素子と異なり耐熱性、耐湿性、耐化学薬品性、レーザ光に対する耐性に非常に優れている。また、マイクロワイヤアレイと称されるもので、赤外線用にアルミニウムの表面を陽極酸化させアルミナとし、微細な穴を開けて中にＮｉやＣｕなどの金属を入れて偏光子としたものがある。さらに、積層型偏光子と称されるものがある。これは、可視光用にはＲＦスパッタリング法で６０～８０Åの厚さのＧｅと、１μm厚さのＳｉＯ₂とを交互に積層して全体の厚みを６０μmとして作製される。０．６μmの波長で測定した性能指数 α_{TE}/α_{TM}（ＴＥ波とＴＭ波に対する消衰定数の比）は４００近く、０．８μmの波長で測定した消光比は３５ｄＢ、挿入損失は０．１８ｄＢであり、可視光に対して十分なものである。

【００２４】
【実施例】以下、上述した構成例に基づく具体的な構成例を実施例１，２として、比較例１～５とともに説明する。

【００２５】＜実施例１＞０．５mm厚の石英基板（透明基板２）上にイオンプレーティング法を用いてＳｉＯ₂（低屈折率の誘電体膜８ａ、屈折率ｎ＝１．４７）を８８．４nm、Ｔａ₂Ｏ₅（高屈折率の誘電体膜８ｂ、屈折率ｎ２．１５）を６０．５nmなる膜厚として交互に６層ずつ、合計１２層積層して誘電体多層膜３を形成した。このときの基板温度は３００℃、酸素ガス圧力はＳｉＯ₂膜の場合で 1.0×10^{-4} Torr 、Ｔａ₂Ｏ₅膜の場合で 1.1×1.0^{-4} Torr であった。成膜レイトはＳｉＯ₂膜の場合で２nm／ｓ、Ｔａ₂Ｏ₅膜の場合で０．５nm／ｓであった。誘電体多層膜３の膜厚分布は、最も厚いところと薄いところとの差異が全膜厚の３％であった。次いで、このような誘電体多層膜３上に、スパッタリング法を用いてＢｉ置換希土類鉄ガーネット膜（透明磁性層４）を平均膜厚が５２０／２＝２６０nmとなるように作製した。このとき、石英基板の前に邪魔板を配置し、さらに、蒸発源直上からの距離を調整して、２mm角の中で、平均膜厚を中心として±１４％膜厚が連続的に変化するように成膜した。このとき、基板温度は４００℃とした。この後、この基板上の膜を空気中、６５０℃で３時間加熱した。膜の組成は、Ｂｉ₂.₂Ｄｙ₀.₈Ｆｅ₃.₈Ａｌ₁.₂Ｏ₁₂であった。磁気光学効果測定装置（日本分光株式会社製のＫ２５０、ビーム径２mm角）で測定したファラデー回転角の波長依存性から、ピークの半値幅を求めると１９nmであった。波長５２０nmでは回転角のピーク値は２．２°であった。ＶＳＭで磁界を膜面に垂直に印加して測定した保磁力は６０００ｅであった。次いで、このようなＢｉ置換希土類鉄ガーネット膜上にイオンプレーティング法を用いて、上述した誘電体多層膜３の場合と全く同様にして、ＳｉＯ₂膜とＴａ₂Ｏ₅膜との誘電体多層膜５を作製した。Ｂｉ置換希土類鉄ガーネット膜に直接接している膜はＴａ₂Ｏ₅膜であり、最表層側はＳｉＯ₂膜である。ファラデー回転角の波長依存性から波長５２０nmでは上記の２．２°に対して約６倍なる１３．０°の回転角となったものである。

【００２６】このような製法を用いて、石英基板上には、誘電体多層膜３／透明磁性層４／誘電体多層膜５なる構造体を２回繰り返して多層構造に形成した。波長５２０nmでは２５．３°のファラデー回転角が得られたものである。また、波長５２０nmを中心とした回転角ピークの半値幅は７８nmであった。以上の積層構造体の最外層を市販されている一対のフィルム偏光子（偏光子６，７）で挟み、そのフィルム偏光子の上から永久磁石（表面磁束密度３ｋガウス）の付いた磁気ペンで文字を書いた。そこで、一対のフィルム偏光子をゆっくりと回転させたところ、磁気ペンで描いた文字が表示（可視化）されたものである。このときの画像部分のコントラストは４．４あり、見やすい表示画像であった。

【００２７】＜比較例１＞Ｂｉ置換希土類鉄ガーネット膜（透明磁性層４）の膜厚に変化を付けずに膜厚が１３

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０ｎｍで均一となるようにこの透明磁性層４を成膜した点以外は、全て実施例１の場合と同様にしてイメージングデバイスを作製したところ（透明磁性層４の膜厚分布は最も厚いところと薄いところとでの差異が全膜厚の４％であった）、波長５２０ｎｍでは２５．７°のファラデー回転角となり、回転角ピークの半値幅は２３ｎｍと狭かったものである。また、一対のフィルム偏光子で挟み、磁気ペンで同様に文字を描いた場合に表示された文字のコントラストは２．９に留まったものである。従って、実施例１のように透明磁性層４の膜厚を連続的に増減変化させることが有効なことが判る。

【００２８】＜比較例２＞石英基板上に形成する誘電体多層膜３は１０層とし、Ｂｉ置換希土類鉄ガーネット膜（透明磁性層４）上に形成する誘電体多層膜５は１５層として、誘電体多層膜３，５の層構造を異ならせる以外は、実施例１の場合と全く同様にしてイメージングデバイスを作製したところ、波長５２０ｎｍでは１８．１°のファラデー回転角となり、回転角ピークの半値幅は４８ｎｍと狭めになったものである。また、一対のフィルム偏光子で挟み、磁気ペンで同様に文字を描いた場合に表示された文字のコントラストは１．７に留まったものである。従って、実施例１のように誘電体多層膜３，５は全く同一に形成することが有効なことが判る。

【００２９】＜比較例３＞Ｂｉ置換希土類鉄ガーネット膜（透明磁性層４）を平均膜厚が５００ｎｍとなるように作製した点以外は、実施例１の場合と全く同様にしてイメージングデバイスを作製したところ、波長５２０ｎｍでは１４．９°のファラデー回転角となり、回転角ピークの半値幅は３０ｎｍと狭くなったものである。また、一対のフィルム偏光子で挟み、磁気ペンで同様に文字を描いた場合に表示された文字のコントラストは２．０に留まったものである。従って、実施例１のように透明磁性層４の膜厚を４００ｎｍ程度以下に形成することが有効なことが判る。

【００３０】＜実施例２＞０．５ｍｍ厚の石英基板（透明基板２）上に実施例１の場合と全く同様にしてＳｉＯ$_2$膜（低屈折率の誘電体膜８ａ）とＴａ$_2$Ｏ$_5$（高屈折率の誘電体膜８ｂ）とによる誘電体多層膜３を形成した。次いで、誘電体多層膜３上に、真空蒸着法を用いて鉄超微粒子膜（透明磁性層４）を平均膜厚が２００ｎｍとなるように作製した。このとき、石英基板の前に１ｍｍ間隔の金属メッシュを配設し、３ｍｍ角の中で平均膜厚を中心として±１６％膜厚が連続的に変化するようにメッシュと基板との間隔を調整して成膜した。このとき、基板温度は常温とした。膜の組成は鉄３９．１ａｔｍｉｃ％、酸素３６．６ａｔｍｉｃ％、炭素２４．０ａｔｍｉｃ％であった。磁気光学効果測定装置で測定したこのときのファラデー回転角の波長依存性を図４に示す。波長５５０ｎｍでは１．６°のファラデー回転角であった。波長５５０ｎｍでの分光透過率は３９．０％であった。また、ＶＳ

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Ｍで磁界を膜面に垂直に印加して測定した保磁力は３２００ｅであった。次いで、このような鉄超微粒子膜上にイオンプレーティング法を用いて、上述した誘電体多層膜３の場合と全く同様にして、ＳｉＯ$_2$膜とＴａ$_2$Ｏ$_5$膜との誘電体多層膜５を作製した。ファラデー回転角の波長依存性から波長５５０ｎｍでは上記の１．６°に対して１５．７°の回転角となったものである。

【００３１】このような製法を用いて、石英基板上には、誘電体多層膜３／透明磁性層４／誘電体多層膜５なる構造体を２回繰り返して多層構造に形成した。波長５５０ｎｍでは２６．４°のファラデー回転角が得られたものである。また、波長５５０ｎｍを中心とした回転角ピークの半値幅は５８ｎｍであった。以上の積層構造体の最外層を市販されている一対のフィルム偏光子で挟み、そのフィルム偏光子の上から永久磁石の付いた磁気ペンで文字を書いた。そこで、一対のフィルム偏光子をゆっくりと回転させたところ、磁気ペンで描いた文字が表示されたものである。このときの画像部分のコントラストは３．３あり、見やすい表示画像であった。

【００３２】＜比較例４＞鉄超微粒子膜（透明磁性層４）の膜厚に変化を付けずに膜厚が２００ｎｍで均一となるようにこの鉄超微粒子膜を成膜した点以外は、全て実施例２の場合と同様にしてイメージングデバイスを作製したところ、波長５５０ｎｍでは１６．０°のファラデー回転角となり、回転角ピークの半値幅は２８ｎｍと狭かったものである。また、一対のフィルム偏光子で挟み、磁気ペンで同様に文字を描いた場合に表示された文字のコントラストは１．７に留まったものである。従って、実施例２のように鉄超微粒子膜（透明磁性層４）の膜厚を連続的に増減変化させることが有効なことが判る。

【００３３】＜比較例５＞石英基板上に形成する誘電体多層膜３／透明磁性層４／誘電体多層膜５の構造体の積層を繰返さず１回のみとした点以外は、実施例２の場合と全く同様にしてイメージングデバイスを作製したところ、波長５５０ｎｍでは７．１°のファラデー回転角となり、回転角ピークの半値幅は４５ｎｍとやや狭めになったものである。また、一対のフィルム偏光子で挟み、磁気ペンで同様に文字を描いた場合に表示された文字のコントラストは１．７であった。従って、実施例２のように誘電体多層膜３／透明磁性層４／誘電体多層膜５の構造体を複数層繰返して形成すれば一層有効なことが判る。

【００３４】
【発明の効果】請求項１記載の発明によれば、膜厚を連続的に増減させた透明磁性層と、屈折率の異なる２種類の多数の誘電体膜が交互に積層されて前記透明磁性層を挟む一対の誘電体多層膜とを備えることで、透明磁性層を一対の誘電体多層膜で挟む構造により基本的に磁気光学効果を増大させ得る上に、増大効果が発揮される波長

を規定する透明磁性層の膜厚が連続的に増減しているので、適用波長範囲を広げることができる。

【００３５】請求項２記載の発明によれば、膜厚を連続的に増減させた透明磁性層と、屈折率の異なる２種類の多数の誘電体膜が交互に積層されて前記透明磁性層を挟む一対の誘電体多層膜とよりなる構造体を複数層積層した構造を備えることで、基本的に請求項１記載の発明の場合と同様に適用波長範囲を広げ得る上に、同一の構造体を複数層積層してなるので、磁気光学効果を一層増大させることができ、ディスプレイ等へ適用した場合の画像コントラストも大幅に向上させることができる。

【００３６】請求項３記載の発明によれば、請求項１又は２記載のイメージングデバイスにおける一対の誘電体多層膜は、材料、積層数、膜厚が全く同一で透明磁性層に対して対称とすることで、一対の誘電体多層膜が同一構造からなるので、磁気光学効果の増大効果を安定して得ることができる。

【００３７】請求項４記載の発明によれば、請求項１，２又は３記載のイメージングデバイスにおける透明磁性層の平均膜厚を１００～４００ｎｍとしたので、画像を形成するためのイメージングデバイスとして標準的な可視光波長域の光を用いることができる。

＊【００３８】請求項５記載の発明によれば、請求項１，２，３又は４記載のイメージングデバイスに加えて、最外層の誘電体多層膜の外面に、互いの偏光軸を回転させてなる一対の偏光子を備えるので、イメージングデバイスに形成された画像をコントラストの高い状態で可視化することができ、ディスプレイ等に好適に応用することができる。

【図面の簡単な説明】

【図１】本発明の一実施の形態のイメージングデバイスの原理的構成を示す断面図である。
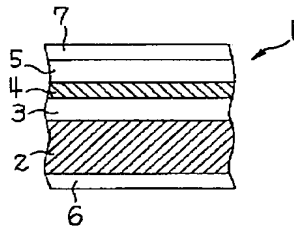
【図２】その誘電体多層膜／透明磁性層／誘電体多層膜構造を示す断面図である。

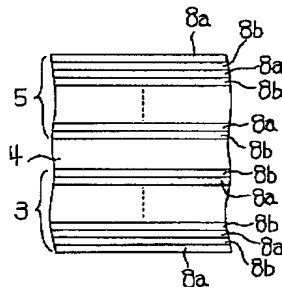【図３】希土類鉄ガーネットのファラデー回転角の波長依存性を示す特性図である。

【図４】鉄超微粒子薄膜のファラデー回転角の波長依存性を示す特性図である。

【符号の説明】

3，5　　　　誘電体多層膜
4　　　　　　透明磁性層
6，7　　　　偏光子
8ａ，8ｂ　　誘電体膜
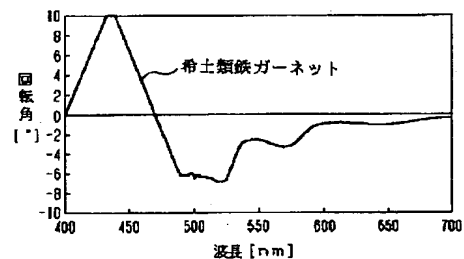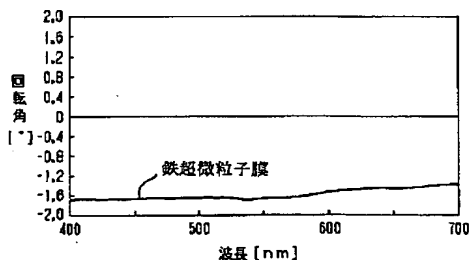
【図１】

【図２】

【図３】

【図４】

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(72)発明者　井上　光輝
　　　　　　宮城県仙台市太白区向山２丁目３の10ヴィ
　　　　　　ラマール向山102

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(21)Application number : 09-357013	(71)Applicant :	RICOH CO LTD
		ARAI KENICHI
(22)Date of filing : 25.12.1997	(72)Inventor :	KATSURAGAWA TADAO
		ARAI KENICHI
		INOUE MITSUTERU

(54) IMAGING DEVICE

(57)Abstract:

PROBLEM TO BE SOLVED: To provide an imaging device capable of obtaining a large magneto- optical effect over a wide wavelength range and sharply improving image contrast.

SOLUTION: Since the imaging device is provided with a transparent magnetic layer 4 of which the film thickness is continuously increased/decreased and a pair of dielectric multi-layer films 3, 5 alternately laminating many dielectric films 8a, 8b of two kinds having respectively different refractive indexes and oppositely arranged through the layer 4, the magneto-electric effect is basically increased by the structure holding the layer 4 between the films 3, 5. Since the film thickness of the layer 4 for regulating wavelength capable of displaying the increment effect of the magneto-electric effect is continuously increased/decreased, an applied wavelength range can be extended.
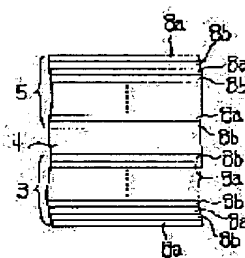
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1.This document has been translated by computer. So the translation may not reflect the original precisely.
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3.In the drawings, any words are not translated.

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CLAIMS

[Claim(s)]
[Claim 1] A imaging device equipped with the dielectric multilayers of the pair to which the laminating of a majority of two kinds of dielectric films with which a refractive index differs from the transparence magnetic layer which made thickness fluctuate continuously is carried out by turns and which pinches said its transparence magnetic layer.
[Claim 2] A imaging device equipped with the structure which carried out two or more layer laminating of the structure which a majority of two kinds of dielectric films with which a refractive index differs from the transparence magnetic layer which made thickness fluctuate continuously become from the dielectric multilayers of the pair said whose transparence magnetic layer a laminating is carried out by turns and pinched.
[Claim 3] An ingredient, the number of laminatings, and thickness are completely the same, and the dielectric multilayers of a pair are symmetrical imaging devices according to claim 1 or 2 to a transparence magnetic layer.
[Claim 4] A transparence magnetic layer is a imaging device according to claim 1, 2, or 3 whose average thickness is 100-400nm.
[Claim 5] The imaging device according to claim 1, 2, 3, or 4 which equips the external surface of the dielectric multilayers of the outermost layer with the polarizer of the pair which makes it come to rotate a mutual polarization shaft.

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[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention is a device for forming an image, and relates to the imaging device which can also apply a display etc. by the visualization.
[0002]
[Description of the Prior Art] Conventionally, the magnetic substance in which the magneto-optical effect (the Faraday effect or magnetooptic Kerr effect) is shown is used for a magneto-optic disk, and informational writing and playback of it are enabled. In addition, the application to the image device for writing in an image using the magnetic head to this transparence magnetic substance using the transparence magnetic substance in which the magneto-optical effect is shown, and forming an image etc. is considered. Moreover, the application to the display which indicates the image by visualization by the existence of Faraday rotation by making light irradiate is also considered.
[0003] It is related with the magneto-optical effect of the discontinuity magnetism medium by which the magnetic substance and an opening have the periodic structure arranged in single dimension by turns here, and a multilayered film with the disordered laminated structure. The analysis about the point that the magneto-optical effect increases as compared with a mere continuation medium, and its result ** ****, Yamamoto, Inoue, Fujii : Institute of Electronics, Information and Communication Engineers Shingaku Giho MR 94-87, "theoretical analysis of the magneto-optics Faraday effect of a discontinuity magnetism medium" of CPM94-112(1995-02) p15-22, ** ****, Yamamoto, Inoue, Fujii:Institute of Electrical Engineers of Japan magnetic study group data Vol.MAG-95-132, "magneto-optical effect of a discontinuity magnetism medium with semi- random single dimension array structure" of No.131-141p9-18 (1995), ** Inoue, Fujii : it is reported by reference, such as "huge enhancement of the magneto-optics Faraday effect by optical localization of a multilayered film with the disordered laminated structure" etc. of the Magnetics Society of Japan 21,187-192 (1997).
[0004] Moreover, the proposal about the magneto-optics component it was made to increase the magneto-optical effect on both sides of the transparence magnetic substance by the dielectric multilayers of a pair is also made by these people.
[0005]
[Problem(s) to be Solved by the Invention] However, although it is not specific wavelength and increase of the magneto-optical effect of the light at large is meant in the above-mentioned proposed example which increases the magneto-optical effect on both sides of the transparence magnetic substance by the dielectric multilayers of a pair, the enhancement effect stops at about at most 2 times.
[0006] Moreover, in order to increase the magneto-optical effect of specific wavelength as shown in the reference of the above-mentioned ** - ** etc., it is possible to choose by controlling strictly the thickness of a transparence magnetic film and the thickness of dielectric multilayers each class. However, the wavelength range which increases inevitably as a result is sharp, and narrow. Therefore, although it can say that it is effective in the case of the laser beam of single wavelength, it is unsuitable for the purpose expected to apply to the light of the larger wavelength range like [in the case of, for example, obtaining the big image of contrast].
[0007] Then, this invention can be crossed to the large wavelength range, can acquire the bigger magneto-optical effect, and aims at offering the imaging device which may raise image contrast sharply.
[0008]
[Means for Solving the Problem] Invention according to claim 1 is equipped with the dielectric multilayers of the pair to which the laminating of a majority of two kinds of dielectric films with which a refractive index differs from the transparence magnetic layer which made thickness fluctuate continuously is carried out by turns and which pinches said its transparence magnetic layer. Therefore, although the magneto-optical effect may be increased according to the structure whose transparence magnetic layer is fundamentally pinched by the dielectric multilayers of a pair, since the thickness of the transparence magnetic layer which specifies the wavelength on which enhancement effect is demonstrated is fluctuating continuously, the application wavelength range can be extended.
[0009] Invention according to claim 2 is equipped with the structure which carried out two or more layer laminating of the structure which a majority of two kinds of dielectric films with which a refractive index differs from the transparence magnetic layer which made thickness fluctuate continuously become from the dielectric multilayers of the pair said whose transparence magnetic layer a laminating is carried out by turns and pinched. Therefore, although the application wavelength range can be fundamentally extended like the case of invention according to claim 1, since it comes to carry out two or more layer laminating of the still more nearly same structure, the magneto-optical effect can be increased further and image contrast can also raise it sharply.
[0010] The dielectric multilayers of the pair in a imaging device according to claim 1 or 2 completely have an ingredient, the number of laminatings, and the same thickness, and that of invention according to claim 3 are symmetrical to a transparence magnetic layer. Therefore, since the dielectric multilayers of a pair consist of the same structure, increase of the magneto-optical effect is stabilized and is acquired.
[0011] The average thickness of a transparence magnetic layer [in / in invention according to claim 4 / a imaging device according to claim 1, 2, or 3] is 100-400nm. Therefore, the light of a wavelength region standard as a imaging device for forming an image can be used.
[0012] In addition to a imaging device according to claim 1, 2, 3, or 4, invention according to claim 5 equips the external surface of the dielectric multilayers of the outermost layer with the polarizer of the pair which makes it come to rotate

a mutual polarization shaft. Therefore, the image formed in the imaging device can be visualized in the high condition of contrast, and it can apply to a display etc.

[0013]

[Embodiment of the Invention] The gestalt of 1 operation of this invention is explained based on a drawing. On the transparence substrate 2, the imaging device 1 of the gestalt of this operation carries out the laminating of the dielectric multilayers 3, the transparence magnetic layer 4, and the dielectric multilayers 5 one by one, and is formed as sandwich structure which sandwiched these laminating structures with the polarizers 6 and 7 of a pair.

[0014] Fundamentally, although set up by lambda/2 to the wavelength lambda which a faraday's rotation angle wants to increase, the thickness of the transparence magnetic layer 4 is formed here from this wavelength lambda with the gestalt of this operation, so that a big faraday's rotation angle may be acquired and the thickness of this transparence magnetic layer 4 may carry out increase and decrease of change continuously, even if it is long wave length and short merit for a while. the wavelength lambda on which the range to change wants to increase [a faraday's rotation angle] — receiving — lambda/— it is good lambda / less than **20% of preferably **30%. For example, what is necessary is just to produce so that the thickness of the transparence magnetic layer 4 may serve as nm (250**25) if it is the case where the faraday's rotation angle of lambda= 500nm wavelength light wants to increase. If the transparence magnetic layer 4 is the case of the thin film by PVD, the continuous inclination (increase and decrease of change) of such thickness is easily realizable with the technique of making a baffle intervene between the inclination of the transparence substrate 2, and the transparence substrate 2 and the source of a steam etc. As long as change of the thickness of the transparence magnetic layer 4 is continuous, it may be good, and it may be a pattern which not necessarily repeats not only monotone increase and decrease but increase and decrease.

[0015] Since the average thickness of the transparence magnetic layer 4 is set up here as mentioned above by one half of the light wavelength lambda, a faraday's rotation angle produces the case of being inadequate, in absolute magnitude. In such a case, the structure to which two or more layer laminating of the structure which consists of 4/dielectric multilayers 5 of 3/transparence magnetic layers of dielectric multilayers on the transparence substrate 2 was carried out as the completely same structure, then sufficient faraday's rotation angle are acquired. If the structure which consists of 4/dielectric multilayers 5 of 3/transparence magnetic layers of dielectric multilayers is repeated twice, a twice [about] as many faraday's rotation angle as this will be acquired (if a laminating is carried out).

[0016] Although it is good at the transparence magnetic material in which the magneto-optical effect generally conventionally used as an ingredient of such a transparence magnetic layer 4 is shown, the so-called large magnetic material of a performance index with the large Faraday effect and large transparency is desirable. For example, the ultrafine particle film of ferromagnetic metals, such as Fe, Co, nickel, etc. which have the particle diameter of 50nm or less, can be used. Oxygen, carbon, etc. are contained in the film presentation of those other than the ultra-fine particle in this case. Although ferromagnetic metals, such as Fe, Co, and nickel, show the big magneto-optical effect, since the absorption of light was also large, it was not used in a thin film as it is, but when it is the ultrafine particle film, it has a big performance index. Moreover, suitable coercive force can be acquired by control of particle diameter. others — oxides, such as a rare earth iron garnet, and a cobalt ferrite, Ba ferrite, $FeBO_3$, FeF_3, $YFeO_3$, and $NdFeO_3$ etc. — ultrafine particles, such as a big ingredient of form birefringence, MnBi, MnCuBi, and PtCo, are also available. Since the biggest effectiveness is acquired when the travelling direction of light and the direction of spin are parallel, as for these transparence magnetic materials, it is [the magneto-optical effect] desirable to form in the direction perpendicular to a film surface as film which has a magnetic anisotropy. PVD, such as the general sputtering method, a vacuum deposition method, and MBE, a CVD method, plating, etc. can be used for production of such a transparence magnetic layer 4.

[0017] Anyway, there is a wavelength dependency of an ingredient proper in the Faraday effect of these magnetic materials. So, when using a magnetic material which was mentioned above, in consideration of the wavelength dependency, the thickness (average thickness) of the transparence magnetic layer 4 must be determined. Drawing 3 shows the wavelength dependency of the faraday's rotation angle in the case of a rare earth iron garnet as an example. And the peak of the faraday's rotation angle near 450nm understands that the contribution to image concentration is few from measurement of spectral transmittance for absorption. Therefore, as for the wavelength which increases a faraday's rotation angle by the dielectric multilayers 3 and 5 in the gestalt of this operation, being referred to as about 520nm is desirable.

[0018] what was formed completely identically [the ingredient, the number of laminatings, thickness, etc.] by the dielectric multilayers 3 and 5 — it is — each and a refractive index — ****** — it comes to carry out the laminating of many dielectric films 8a and 8b whose number is two as one pair Although especially the number of pairs does not have a limit, it is desirable on the engine performance and cost to consider as 3 – 20 pair extent. Moreover, since the dielectric film 8a same as a membranous class at the dielectric multilayers 3 and 5 or 8b which touches the transparence magnetic layer 4 directly is used, as shown in drawing 2 , built-up sequence becomes reverse. That is, the dielectric multilayers 3 and 5 are made into symmetry structure to the transparence magnetic layer 4. Although Ta_2O_5 grade can be used for the ingredient of dielectric films 8a and 8b as SiO_2 and dielectric film 8b as dielectric film 8a, various ingredients as shown in Table 1 including these can be used for it here. You may choose suitably from these ingredients, or it does not matter even if it is ingredients other than this, for example, the organic substance. Each thickness of dielectric films 8a and 8b has desirable about 50-200nm. If it is the case where it aims at increase of the magneto-optical effect of the specific wavelength lambda, the thickness of dielectric films 8a and 8b may be lambda/4n (refractive index of a dielectric [in / in n / wavelength lambda]).

[0019]

[Table 1]

	物　　質	屈折率(波長(nm))	透明波長域
n＜1.5	calcium fluoride(CaF$_2$)	1.23～1.26(546)	150nm～12μm
	sodium fluoride(NaF)	1.34　(550)	250nm～14μm
	cryolite(Na$_3$AlF$_6$)	1.35　(550)	＜200nm～14μm
	lithium fluoride(LiF)	1.36～1.37(546)	110nm～7μm
	magnesium fluoride(MgF$_2$)	1.38　(550)	210nm～10μm
	silicon dioxide(SiO$_2$)	1.46　(500)	＜200nm～8μm
1.5＜n＜2	lanthanum fluoride(LaF$_3$)	1.59　(550)	220nm～＞2μm
	neodymium fluoride(NdF$_3$)	1.6　(550)	220nm～＞2μm
	aluminum oxide(Al$_2$O$_3$)	1.62　(600)	
	cerium fluoride(CeF$_3$)	1.63　(550)	300nm～＞5μm
	lead fluoride(PbF$_2$)	1.75　(550)	240nm～＞20μm
	magnesium oxide(MgO)	1.75　(500)	
	thorium oxide(ThO$_2$)	1.8　(550)	250nm～＞2μm
	tin oxide(SnO$_2$)	1.9　(550)	
	lanthanum oxide(La$_2$O$_3$)	1.95　(550)	350nm～＞2μm
	silicon monoxide(SiO)	1.7～2.0　(550)	500nm～　8μm
2＜n＜3	indium oxide(In$_2$O$_3$)	2.0　(500)	
	neodymium oxide(Nd$_2$O$_3$)	2.0　(550)	400nm～＞2μm
	antimony trioxide(Sb$_2$O$_3$)	2.04　(546)	300nm～＞1μm
	zirconium oxide(ZrO$_2$)	2.1　(550)	
	cerium dioxide(CeO$_2$)	2.2　(550)	400nm～10μm
	titanium dioxide(TiO$_2$)	2.2～2.7　(550)	350nm～12μm
	zinc sulfide(ZnS)	2.35　(550)	380nm～25μm
	bismuth oxide(Bi$_2$O$_3$)	2.45　(550)	
	zinc selenide(ZnSe)	2.58　(633)	600nm～＞15μm
	cadmium sulfide(CdS)	2.6　(600)	600nm～7μm
3＜n	antimony-sulfide(Sb$_2$S$_3$)	3.0　(589)	500nm～10μm
	cadmium telluride(CdTe)	3.05　(IR)	
	silicon(Si)	3.5	1.1nm～10μm
	germanium(Ge)	4.0	1.7nm～100μm
	tellurium(Te)	4.9　(6μm)	3.4nm～20μm
	lead telluride(PbTe)	5.5	3.4nm～30μm

[0020] As a transparence substrate 2, quartz glass, sapphire, crystallization clear glass, Pyrex glass, aluminum 2O3, MgO, BeO and ZrO2, Y2O3, ThO2 and CaO, Inorganic transparent materials, such as GGG (gadolinium gallium garnet), MMA, PMMA, a polycarbonate, polypropylene, acrylic resin, Styrene resin, ABS plastics, polyarylate, Pori Sall John, a polyether ape phon, Transparence plastic film, such as an epoxy resin, Pori-4-methyl pentene-1, fluorination polyimide, a fluororesin, phenoxy resin, polyolefine system resin, and Nylon, is used. Since there are advantages, such as light bending, a light cone, etc., when transparence plastic film is used, it is easy to use.

[0021] Polarizers 6 and 7 are used in the becoming configuration for visualizing as an image the big faraday's rotation angle acquired by the part by which the transparence magnetic layer 4 was magnetized 3/transparence substrate 2 of 4/dielectric multilayers of 5/transparence magnetic layers of dielectric multilayers. Namely, since the plane of polarization of light does not rotate by the part which is not magnetized to a big faraday's rotation angle being acquired corresponding to the part where the transparence magnetic layer 4 was magnetized If the polarization shaft (absorption or transparency shaft) of the polarizers 6 and 7 of a pair is rotated so that contrast may become the largest by the plane-of-polarization rotation part and the nonrotation part By the plane-of-polarization rotation part, in a nonrotation part, it is white because of the transmitted light, and since both the polarizers 6 and 7 cannot be passed, it will look black, and an image is visualized.

[0022] As such polarizers 6 and 7, the polarization film of various kinds of marketing, the high permeability polarizer which used the beam splitter can be used. When a polarization film is divided roughly, it has a multi-halogen polarization film, a color polarization film, a metal polarization film, etc. Although it has a property [flat / field / at large / light] since the multi-halogen polarization film uses iodine for the dichroic matter, on the other hand, humidity, an elevated temperature, etc. have the fault of being weak. Although a color polarization film is inferior to iodine in polarizability, it has the features that resistance is large, to heat, light, and humidity. Anyway, since a flaw tends to be attached, as for the front face (exposure) of polarizers 6 and 7, it is desirable to prepare a protective coat in fact.

[0023] Moreover, as polarizers 6 and 7, various kinds of polarizers which are illustrated below can also be used. For example, as shown in JP,1-93702,A, by arranging the polarization layer containing many cylindrical components which consist of a ferromagnetic particle in the fixed direction on a substrate front face, and carrying out fixing formation, manufacture is easy and there is a polarizing plate excellent in the optical property. Moreover, Tokyo University of Agriculture and Technology Professor Katsuaki Sato work "physical 1-light [of a man of today] and MAG" (1988 publication) p103 There is a wire grid polarizer indicated. From 2.5 micrometers, this is a polarizer to the light of long wavelength, and draws the line of gold or aluminum at minute spacing to transparence substrates (a silver bromide, polyethylene, etc.). If spacing of a line is set to d and wavelength is set to lambda, it will use that the transmitted light turns into the nearly perfect linearly polarized light with a plane of vibration perpendicular to a line to the wavelength light which becomes lambda＞＞d. That to which what drew the gold streak at intervals of d= 0.3 micrometers to the

silver-bromide substrate drew the aluminium wire by d= 0.7 micrometers to the polyethylene plate as an object (16-100 micrometers) for far-infrared rays as an object (2.5-25 micrometers) for inside infrared rays is used. Moreover, there is a Poral core (trade name) by Corning, Inc. By making an one direction arrange the metal silver made to extend for a long time in [glass's] an own one, this is glass which gave the polarization property and, unlike the conventional organic substance polarizing element, is very excellent in thermal resistance, moisture resistance, resistance to chemicals, and the resistance over a laser beam. Moreover, there are some which are called a micro wire array, the front face of aluminum was made to anodize for infrared radiation, and used as the alumina, made the detailed hole, put metals, such as nickel and Cu, into inside, and were used as the polarizer. Furthermore, there are some which are called a laminating mold polarizer. This carries out the laminating of germanium with a thickness of 60-80A and SiO2 of 1-micrometer thickness by turns by the RF sputtering method to the lights, and the whole thickness is produced as 60 micrometers. The extinction ratio measured on about 400 and the wavelength of 0.8 micrometers is 35dB, an insertion loss is 0.18dB, and performance-index alpha TE/alpha TM (ratio of an extinction constant to a TE wave and a TM wave) measured on the wavelength of 0.6 micrometers is enough to the light.
[0024]
[Example] Hereafter, the concrete example of a configuration based on the example of a configuration mentioned above is explained with the examples 1-5 of a comparison as examples 1 and 2.
[0025] the quartz substrate (transparence substrate 2) top of 1> 0.5mm thickness of < examples — the ion plating method — using — SiO2 (dielectric film 8a [of a low refractive index], refractive index n= 1.47) — 88.4nm and Ta 2O5 (dielectric film 8b [of a high refractive index], refractive index n2.15) — 60.5nm — it considered as thickness, and by turns, a total of 12-layer laminating was carried out, and it formed six layers of dielectric multilayers 3 at a time. the substrate temperature at this time — 300 degrees C and the oxygen-gas-pressure force — SiO2 the case of the film — the case of 2O1.0x10~4Torr and Ta5 film — 1.1x10~4Torr it was . Membrane formation Leto is SiO2. In the case of film, in the case of [2O2 nm/s and Ta5], they were 0.5 nm/s. The differences between the place where thickness distribution of the dielectric multilayers 3 is the thickest, and a thin place were 3% of all thickness. Subsequently, on such dielectric multilayers 3, the sputtering method was used, and Bi permutation rare earth iron garnet film (transparence magnetic layer 4) was produced so that average thickness might be set to 520 / 2= 260nm. At this time, further, the baffle has been arranged in front of a quartz substrate, and the distance from right above [evaporation source] was adjusted, and membranes were formed so that thickness might change continuously **14% focusing on average thickness in 2mm angle. Substrate temperature was made into 400 degrees C at this time. Then, the film on this substrate was heated at 650 degrees C among air for 3 hours. The membranous presentation was Bi2.2Dy0.8Fe3.8aluminum 1.2O12. It was 19nm when asked for the full width at half maximum from the wavelength dependency of the faraday's rotation angle measured with the magneto-optical-effect measuring device (K250 by Jasco Corp., beam diameter angle of 2mm). On the wavelength of 520nm, the peak value of an angle of rotation was 2.2 degrees. The coercive force which impressed the field at right angles to a film surface, and measured it by VSM was 600Oe(s). Subsequently, it is SiO2 completely like the case of the dielectric multilayers 3 which used the ion plating method on such Bi permutation rare earth iron garnet film, and were mentioned above. The dielectric multilayers 5 of the film and 2OTa5 film were produced. The film which is directly in contact with Bi permutation rare earth iron garnet film is 2OTa5 film, and the maximum surface side is SiO2. It is the film. On the wavelength of 520nm, it becomes the 13.0-degree angle of rotation which becomes about 6 times to the above-mentioned 2.2 degrees from the wavelength dependency of a faraday's rotation angle.
[0026] Using such a process, on the quartz substrate, the structure which becomes 4/dielectric multilayers 5 of 3/transparence magnetic layers of dielectric multilayers was repeated twice, and it formed at multilayer structure. A 25.3-degree faraday's rotation angle is acquired on the wavelength of 520nm. Moreover, the angle-of-rotation full width at half maximum centering on the wavelength of 520nm was 78nm. It inserted with the film polarizer (polarizers 6 and 7) of the pair which is having the outermost layer of the above laminating structure marketed, and the alphabetic character was written with the magnetic pen to which the permanent magnet (surface-inductive-flux 3k gauss) was attached from on the film polarizer. Then, when the film polarizer of a pair is rotated slowly, the alphabetic character drawn with the magnetic pen is displayed (visualization). The contrast of the image part at this time was those with 4.4, and a legible display image.
[0027] Except the point which formed this transparence magnetic layer 4 so that thickness might become uniform by 130nm, without giving change to the thickness of the <example 1 of comparison> Bi permutation rare earth iron garnet film (transparence magnetic layer 4) The place which produced the imaging device like the case of an example 1 altogether (the differences in the place where thickness distribution of the transparence magnetic layer 4 is the thickest, and a thin place were 4% of all thickness), On the wavelength of 520nm, it becomes a 25.7-degree faraday's rotation angle, and the angle-of-rotation full width at half maximum is as narrow as 23nm. Moreover, it inserts with the film polarizer of a pair and the contrast of the alphabetic character displayed when an alphabetic character was similarly drawn with a magnetic pen stops at 2.9. Therefore, it turns out that it is effective to carry out increase and decrease of the thickness of the transparence magnetic layer 4 of change continuously like an example 1.
[0028] The dielectric multilayers 5 which the dielectric multilayers 3 formed on the <example 2 of comparison> quartz substrate make ten layers, and are formed on Bi permutation rare earth iron garnet film (transparence magnetic layer 4) as 15 layers When a imaging device is produced completely like the case of an example 1 except changing the layer structure of the dielectric multilayers 3 and 5, on the wavelength of 520nm, it becomes a 18.1-degree faraday's rotation angle, and the angle-of-rotation full width at half maximum becomes 48nm and straitness. Moreover, it inserts with the film polarizer of a pair and the contrast of the alphabetic character displayed when an alphabetic character was similarly drawn with a magnetic pen stops at 1.7. Therefore, the dielectric multilayers 3 and 5 are understood that completely forming identically is effective like an example 1.
[0029] Except the point which produced the <example 3 of comparison> Bi permutation rare earth iron garnet film (transparence magnetic layer 4) so that average thickness might be set to 500nm, when a imaging device is produced completely like the case of an example 1, on the wavelength of 520nm, it becomes a 14.9-degree faraday's rotation angle, and the angle-of-rotation full width at half maximum becomes narrow with 30nm. Moreover, it inserts with the film polarizer of a pair and the contrast of the alphabetic character displayed when an alphabetic character was similarly drawn with a magnetic pen stops at 2.0. Therefore, it turns out that it is effective to form the thickness of the transparence magnetic layer 4 in about 400nm or less like an example 1.
[0030] It is SiO2 completely like the case of an example 1 on the quartz substrate (transparence substrate 2) of 2>

0.5mm thickness of < examples. The dielectric multilayers 3 by the film (dielectric film 8a of a low refractive index) and Ta 2O5 (dielectric film 8b of a high refractive index) were formed. Subsequently, on the dielectric multilayers 3, the vacuum deposition method was used, and the iron ultrafine particle film (transparence magnetic layer 4) was produced so that average thickness might be set to 200nm. At this time, the metal mesh of 1mm spacing was arranged in front of the quartz substrate, and spacing of a mesh and a substrate was adjusted and membranes were formed so that thickness might change continuously **16% focusing on average thickness in 3mm angle. Substrate temperature was made into ordinary temperature at this time. a membranous presentation — iron 39.1atmic% and oxygen 36.6atmic% and carbon 24.0atmic% it was . The wavelength dependency of this faraday's rotation angle when measuring with a magneto-optical-effect measuring device is shown in <u>drawing 4</u> . On the wavelength of 550nm, it was a 1.6-degree faraday's rotation angle. Spectral transmittance with a wavelength of 550nm was 39.0%. Moreover, the coercive force which impressed the field at right angles to a film surface, and measured it by VSM was 320Oe(s). Subsequently, it is SiO2 completely like the case of the dielectric multilayers 3 which used the ion plating method on such iron ultrafine particle film, and were mentioned above. The dielectric multilayers 5 of the film and 2OTa5 film were produced. On the wavelength of 550nm, it becomes a 15.7-degree angle of rotation from the wavelength dependency of a faraday's rotation angle to the above-mentioned 1.6 degrees.

[0031] Using such a process, on the quartz substrate, the structure which becomes 4/dielectric multilayers 5 of 3/transparence magnetic layers of dielectric multilayers was repeated twice, and it formed at multilayer structure. A 26.4-degree faraday's rotation angle is acquired on the wavelength of 550nm. Moreover, the angle-of-rotation full width at half maximum centering on the wavelength of 550nm was 58nm. It inserted with the film polarizer of the pair which is having the outermost layer of the above laminating structure marketed, and the alphabetic character was written with the magnetic pen to which the permanent magnet was attached from on the film polarizer. Then, when the film polarizer of a pair is rotated slowly, the alphabetic character drawn with the magnetic pen is displayed. The contrast of the image part at this time was those with 3.3, and a legible display image.

[0032] When a imaging device is produced like the case of an example 2 except [all] the point which formed this iron ultrafine particle film so that thickness might become uniform by 200nm, without giving change to the thickness of the <example 4 of comparison> iron ultrafine particle film (transparence magnetic layer 4), on the wavelength of 550nm, it becomes a 16.0-degree faraday's rotation angle, and the angle-of-rotation full width at half maximum is as narrow as 28nm. Moreover, it inserts with the film polarizer of a pair and the contrast of the alphabetic character displayed when an alphabetic character was similarly drawn with a magnetic pen stops at 1.7. Therefore, it turns out that it is effective to carry out increase and decrease of the thickness of the iron ultrafine particle film (transparence magnetic layer 4) of change continuously like an example 2.

[0033] When a imaging device is produced completely like the case of an example 2 except the point which did not repeat the laminating of the structure of the 4/dielectric multilayers 5 of 3/transparence magnetic layers of dielectric multilayers formed on the <example 5 of comparison> quartz substrate, but was made only into 1 time, on the wavelength of 550nm, it becomes a 7.1-degree faraday's rotation angle, and the angle-of-rotation full width at half maximum is set a little to 45nm to slight straitness. Moreover, the contrast of the alphabetic character displayed when it inserted with the film polarizer of a pair and an alphabetic character was similarly drawn with a magnetic pen was 1.7. Therefore, if two or more layer loop of the structure of the 4/dielectric multilayers 5 of 3/transparence magnetic layers of dielectric multilayers is carried out and it is formed like an example 2, it turns out that it is much more effective.

[0034]
[Effect of the Invention] By having the dielectric multilayers of the pair to which the laminating of a majority of two kinds of dielectric films with which a refractive index differs from the transparence magnetic layer which made thickness fluctuate continuously is carried out by turns and which pinches said its transparence magnetic layer according to invention according to claim 1 Since the thickness of the transparence magnetic layer which specifies the wavelength on which the magneto-optical effect may be fundamentally increased upwards according to the structure whose transparence magnetic layer is pinched by the dielectric multilayers of a pair, and enhancement effect is demonstrated is fluctuating continuously, the application wavelength range can be extended.

[0035] The transparence magnetic layer which made thickness fluctuate continuously according to invention according to claim 2, By having the structure which carried out two or more layer laminating of the structure which a majority of two kinds of dielectric films with which refractive indexes differ become from the dielectric multilayers of the pair said whose transparence magnetic layer a laminating is carried out by turns and pinched Since the application wavelength range can be fundamentally extended upwards like the case of invention according to claim 1 and it comes to carry out two or more layer laminating of the same structure, the magneto-optical effect can be increased further and the image contrast at the time of applying to a display etc. can also be raised sharply.

[0036] According to invention according to claim 3, the dielectric multilayers of the pair in a imaging device according to claim 1 or 2 completely have an ingredient, the number of laminatings, and the same thickness, and by supposing that it is symmetrical to a transparence magnetic layer, since the dielectric multilayers of a pair consist of the same structure, it is stabilized and they can obtain the enhancement effect of the magneto-optical effect.

[0037] According to invention according to claim 4, since average thickness of the transparence magnetic layer in a imaging device according to claim 1, 2, or 3 was set to 100-400nm, the light of a light wavelength region standard as a imaging device for forming an image can be used.

[0038] According to invention according to claim 5, since it has the polarizer of the pair which makes the external surface of the dielectric multilayers of the outermost layer come to rotate a mutual polarization shaft in addition to a imaging device according to claim 1, 2, 3, or 4, the image formed in the imaging device can be visualized in the high condition of contrast, and can be suitably applied to a display etc.

[Translation done.]

TECHNICAL FIELD

[Field of the Invention] This invention is a device for forming an image, and relates to the imaging device which can also apply a display etc. by the visualization.

[Translation done.]

PRIOR ART

[Description of the Prior Art] From the former, it is the magneto-optical effect.

[Translation done.]

EFFECT OF THE INVENTION

The magnetic substance in which (the Faraday effect or a magnetooptic Kerr effect) is shown is used for a magneto-optic disk, and informational writing and playback of it are enabled. In addition, the application to the image device for writing in an image using the magnetic head to this transparence magnetic substance using the transparence magnetic substance in which the magneto-optical effect is shown, and forming an image etc. is considered. Moreover, the application to the display which indicates the image by visualization by the existence of Faraday rotation by making light irradiate is also considered.
[0003] It is related with the magneto-optical effect of the discontinuity magnetism medium by which the magnetic substance and an opening have the periodic structure arranged in single dimension by turns here, and a multilayered film with the disordered laminated structure, The analysis about the point that the magneto-optical effect increases as compared with a mere continuation medium, and its result are ** ****, Yamamoto, Inoue, and the Fujii:Institute of Electronics, Information and Communication Engineers. Shingaku Giho MR 94-87, "the theoretical analysis of the magneto-optics Faraday effect of a discontinuity magnetism medium" of CPM94-112(1995-02) p15-22, ** ****, Yamamoto, Inoue, Fujii:Institute of Electrical Engineers of Japan magnetic study group data Vol.MAG-95-132, and No.131-141p9-18 (1995)

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, although it is not specific wavelength and increase of the magneto-optical effect of the light at large is meant in the above-mentioned proposed example which increases the magneto-optical effect on both sides of the transparence magnetic substance by the dielectric multilayers of a pair, the enhancement effect stops at about at most 2 times.
[0006] Moreover, in order to increase the magneto-optical effect of specific wavelength as shown in the reference of the above-mentioned ** - ** etc., it is possible to choose by controlling strictly the thickness of a transparence magnetic film and the thickness of dielectric multilayers each class. However, the wavelength range which increases inevitably as a result is sharp, and narrow. Therefore, although it can say that it is effective in the case of the laser beam of single wavelength, it is unsuitable for the purpose expected to apply to the light of the larger wavelength range like [in the case of, for example, obtaining the big image of contrast].
[0007] Then, this invention can be crossed to the large wavelength range, can acquire the bigger magneto-optical effect, and aims at offering the imaging device which may raise image contrast sharply.

[Translation done.]

MEANS

[Means for Solving the Problem] Invention according to claim 1 is equipped with the dielectric multilayers of the pair to which the laminating of a majority of two kinds of dielectric films with which a refractive index differs from the transparence magnetic layer which made thickness fluctuate continuously is carried out by turns and which pinches said its transparence magnetic layer. Therefore, although the magneto-optical effect may be increased according to the structure whose transparence magnetic layer is fundamentally pinched by the dielectric multilayers of a pair, since the thickness of the transparence magnetic layer which specifies the wavelength on which enhancement effect is demonstrated is fluctuating continuously, the application wavelength range can be extended.

[0009] Invention according to claim 2 is equipped with the structure which carried out two or more layer laminating of the structure which a majority of two kinds of dielectric films with which a refractive index differs from the transparence magnetic layer which made thickness fluctuate continuously become from the dielectric multilayers of the pair said whose transparence magnetic layer a laminating is carried out by turns and pinched. Therefore, although the application wavelength range can be fundamentally extended like the case of invention according to claim 1, since it comes to carry out two or more layer laminating of the still more nearly same structure, the magneto-optical effect can be increased further and image contrast can also raise it sharply.

[0010] The dielectric multilayers of the pair in a imaging device according to claim 1 or 2 completely have an ingredient, the number of laminatings, and the same thickness, and that of invention according to claim 3 are symmetrical to a transparence magnetic layer. Therefore, since the dielectric multilayers of a pair consist of the same structure, increase of the magneto-optical effect is stabilized and is acquired.

[0011] The average thickness of a transparence magnetic layer [in / in invention according to claim 4 / a imaging device according to claim 1, 2, or 3] is 100-400nm. Therefore, the light of a wavelength region standard as a imaging device for forming an image can be used.

[0012] In addition to a imaging device according to claim 1, 2, 3, or 4, invention according to claim 5 equips the external surface of the dielectric multilayers of the outermost layer with the polarizer of the pair which makes it come to rotate a mutual polarization shaft. Therefore, the image formed in the imaging device can be visualized in the high condition of contrast, and it can apply to a display etc.

[0013]
[Embodiment of the Invention] The gestalt of 1 operation of this invention is explained based on a drawing. On the transparence substrate 2, the imaging device 1 of the gestalt of this operation carries out the laminating of the dielectric multilayers 3, the transparence magnetic layer 4, and the dielectric multilayers 5 one by one, and is formed as sandwich structure which sandwiched these laminating structures with the polarizers 6 and 7 of a pair.

[0014] Fundamentally, although set up by lambda/2 to the wavelength lambda which a faraday's rotation angle wants to increase, the thickness of the transparence magnetic layer 4 is formed here from this wavelength lambda with the gestalt of this operation, so that a big faraday's rotation angle may be acquired and the thickness of this transparence magnetic layer 4 may carry out increase and decrease of change continuously, even if it is long wave length and short merit for a while. the wavelength lambda on which the range to change wants to increase [a faraday's rotation angle] — receiving — lambda/— it is good lambda / less than **20% of preferably **30%. For example, what is necessary is just to produce so that the thickness of the transparence magnetic layer 4 may serve as nm (250**25) if it is the case where the faraday's rotation angle of lambda= 500nm wavelength light wants to increase. If the transparence magnetic layer 4 is the case of the thin film by PVD, the continuous inclination (increase and decrease of change) of such thickness is easily realizable with the technique of making a baffle intervene between the inclination of the transparence substrate 2, and the transparence substrate 2 and the source of a steam etc. As long as change of the thickness of the transparence magnetic layer 4 is continuous, it may be good, and it may be a pattern which not necessarily repeats not only monotone increase and decrease but increase and decrease.

[0015] Since the average thickness of the transparence magnetic layer 4 is set up here as mentioned above by one half of the light wavelength lambda, a faraday's rotation angle produces the case of being inadequate, in absolute magnitude. In such a case, the structure to which two or more layer laminating of the structure which consists of 4/dielectric multilayers 5 of 3/transparence magnetic layers of dielectric multilayers on the transparence substrate 2 was carried out as the completely same structure, then sufficient faraday's rotation angle are acquired. If the structure which consists of 4/dielectric multilayers 5 of 3/transparence magnetic layers of dielectric multilayers is repeated twice, a twice [about] as many faraday's rotation angle as this will be acquired (if a laminating is carried out).

[0016] Although it is good at the transparence magnetic material in which the magneto-optical effect generally conventionally used as an ingredient of such a transparence magnetic layer 4 is shown, the so-called large magnetic material of a performance index with the large Faraday effect and large transparency is desirable. For example, the ultrafine particle film of ferromagnetic metals, such as Fe, Co, nickel, etc. which have the particle diameter of 50nm or less, can be used. Oxygen, carbon, etc. are contained in the film presentation of those other than the ultra-fine particle in this case. Although ferromagnetic metals, such as Fe, Co, and nickel, show the big magneto-optical effect, since the absorption of light was also large, it was not used in a thin film as it is, but when it is the ultrafine particle film, it has a big performance index. Moreover, suitable coercive force can be acquired by control of particle diameter. others — oxides, such as a rare earth iron garnet, and a cobalt ferrite, Ba ferrite, FeBO3, FeF3, YFeO3, and NdFeO3 etc. — ultrafine particles, such as a big ingredient of form birefringence, MnBi, MnCuBi, and PtCo, are also available. Since the biggest effectiveness is acquired when the travelling direction of light and the direction of spin are parallel, as for these transparence magnetic materials, it is [the magneto-optical effect] desirable to form in the direction perpendicular to

a film surface as film which has a magnetic anisotropy. PVD, such as the general sputtering method, a vacuum deposition method, and MBE, a CVD method, plating, etc. can be used for production of such a transparence magnetic layer 4.

[0017] Anyway, there is a wavelength dependency of an ingredient proper in the Faraday effect of these magnetic materials. So, when using a magnetic material which was mentioned above, in consideration of the wavelength dependency, the thickness (average thickness) of the transparence magnetic layer 4 must be determined. Drawing 3 shows the wavelength dependency of the faraday's rotation angle in the case of a rare earth iron garnet as an example. And the peak of the faraday's rotation angle near 450nm understands that the contribution to image concentration is few from measurement of spectral transmittance for absorption. Therefore, as for the wavelength which increases a faraday's rotation angle by the dielectric multilayers 3 and 5 in the gestalt of this operation, being referred to as about 520nm is desirable.

[0018] what was formed completely identically [the ingredient, the number of laminatings, thickness, etc.] by the dielectric multilayers 3 and 5 — it is — each and a refractive index — ****** — it comes to carry out the laminating of many dielectric films 8a and 8b whose number is two as one pair Although the number of pairs does not have a limit, it is desirable on the engine performance and cost to consider as 3 - 20 pair extent. Moreover, since the dielectric film 8a same as a membranous class at the dielectric multilayers 3 and 5 or 8b which touches the transparence magnetic layer 4 directly is used, as shown in drawing 2 , built-up sequence becomes reverse. That is, the dielectric multilayers 3 and 5 are made into symmetry structure to the transparence magnetic layer 4. Although Ta2O5 grade can be used for the ingredient of dielectric films 8a and 8b as SiO2 and dielectric film 8b as dielectric film 8a, various ingredients as shown in Table 1 including these can be used for it here. You may choose suitably from these ingredients, or it does not matter even if it is ingredients other than this, for example, the organic substance. Each thickness of dielectric films 8a and 8b has desirable about 50-200nm. If it is the case where it aims at increase of the magneto-optical effect of the specific wavelength lambda, the thickness of dielectric films 8a and 8b may be lambda/4n (refractive index of a dielectric [in / in n / wavelength lambda]).

[0019]
[Table 1]

	物　　質	屈折率(波長(nm))	透明波長域
n<1.5	calcium fluoride(CaF_2)	1.23~1.26(546)	150nm~12μm
	sodium fluoride(NaF)	1.34 (550)	250nm~14μm
	cryolite(Na_3AlF_6)	1.35 (550)	<200nm~14μm
	lithium fluoride(LiF)	1.36~1.37(546)	110nm~7μm
	magnesium fluoride(MgF_2)	1.38 (550)	210nm~10μm
	silicon dioxide(SiO_2)	1.46 (500)	<200nm~8μm
1.5<n<2	lanthanum fluoride(LaF_3)	1.59 (550)	220nm~>2μm
	neodymium fluoride(NdF_3)	1.6 (550)	220nm~>2μm
	aluminum oxide(Al_2O_3)	1.62 (600)	
	cerium fluoride(CeF_3)	1.63 (550)	300nm~>5μm
	lead fluoride(PbF_2)	1.75 (550)	240nm~>20μm
	magnesium oxide(MgO)	1.75 (500)	
	thorium oxide(ThO_2)	1.8 (550)	250nm~>2μm
	tin oxide(SnO_2)	1.9 (550)	
	lanthanum oxide(La_2O_3)	1.95 (550)	350nm~>2μm
	silicon monoxide(SiO)	1.7~2.0 (550)	500nm~ 8μm
2<n<3	indium oxide(In_2O_3)	2.0 (500)	
	neodymium oxide(Nd_2O_3)	2.0 (550)	400nm~>2μm
	antimony trioxide(Sb_2O_3)	2.04 (546)	300nm~>1μm
	zirconium oxide(ZrO_2)	2.1 (550)	
	cerium dioxide(CeO_2)	2.2 (550)	400nm~10μm
	titanium dioxide(TiO_2)	2.2~2.7 (550)	350nm~12μm
	zinc sulfide(ZnS)	2.35 (550)	380nm~25μm
	bismuth oxide(Bi_2O_3)	2.45 (550)	
	zinc selenide(ZnSe)	2.58 (633)	600nm~>15μm
	cadmium sulfide(CdS)	2.6 (600)	600nm~7μm
3<n	antimony-sulfide(Sb_2S_3)	3.0 (589)	500nm~10μm
	cadmium telluride(CdTe)	3.05 (IR)	
	silicon(Si)	3.5	1.1nm~10μm
	germanium(Ge)	4.0	1.7nm~100μm
	tellurium(Te)	4.9 (6μm)	3.4nm~20μm
	lead telluride(PbTe)	5.5	3.4nm~30μm

[0020] As a transparence substrate 2, quartz glass, sapphire, crystallization clear glass, Pyrex glass, aluminum 2O3, MgO, BeO and ZrO2, Y2O3, ThO2 and CaO, Inorganic transparent materials, such as GGG (gadolinium gallium garnet), MMA, PMMA, a polycarbonate, polypropylene, acrylic resin, Styrene resin, ABS plastics, polyarylate, Pori Sall John, a polyether ape phon, Transparence plastic film, such as an epoxy resin, Pori-4-methyl pentene-1, fluorination polyimide, a fluororesin, phenoxy resin, polyolefine system resin, and Nylon, is used. Since there are advantages, such as light bending, a light cone, etc., when transparence plastic film is used, it is easy to use.

[0021] Polarizers 6 and 7 are used in the becoming configuration for visualizing as an image the big faraday's rotation angle acquired by the part by which the transparence magnetic layer 4 was magnetized 3/transparence substrate 2 of 4/dielectric multilayers of 5/transparence magnetic layers of dielectric multilayers. Namely, since the plane of polarization of light does not rotate by the part which is not magnetized to a big faraday's rotation angle being acquired corresponding to the part where the transparence magnetic layer 4 was magnetized If the polarization shaft (absorption or transparency shaft) of the polarizers 6 and 7 of a pair is rotated so that contrast may become the largest by the plane-of-polarization rotation part and the nonrotation part By the plane-of-polarization rotation part, in a nonrotation part, it is white because of the transmitted light, and since both the polarizers 6 and 7 cannot be passed, it will look black, and an image is visualized.

[0022] As such polarizers 6 and 7, the polarization film of various kinds of marketing, the high permeability polarizer which used the beam splitter can be used. When a polarization film is divided roughly, it has a multi-halogen polarization film, a color polarization film, a metal polarization film, etc. Although it has a property [flat / field / at large / light] since the multi-halogen polarization film uses iodine for the dichroic matter, on the other hand, humidity, an elevated temperature, etc. have the fault of being weak. Although a color polarization film is inferior to iodine in polarizability, it has the features that resistance is large, to heat, light, and humidity. Anyway, since a flaw tends to be attached, as for the front face (exposure) of polarizers 6 and 7, it is desirable to prepare a protective coat in fact.

[0023] Moreover, as polarizers 6 and 7, various kinds of polarizers which are illustrated below can also be used. For example, as shown in JP,1-93702,A, by arranging the polarization layer containing many cylindrical components which consist of a ferromagnetic particle in the fixed direction on a substrate front face, and carrying out fixing formation, manufacture is easy and there is a polarizing plate excellent in the optical property. Moreover, Tokyo University of Agriculture and Technology Professor Katsuaki Sato work "physical 1-light [of a man of today] and MAG" (1988 publication) p103 There is a wire grid polarizer indicated. From 2.5 micrometers, this is a polarizer to the light of long wavelength, and draws the line of gold or aluminum at minute spacing to transparence substrates (a silver bromide, polyethylene, etc.). If spacing of a line is set to d and wavelength is set to lambda, it will use that the transmitted light turns into the nearly perfect linearly polarized light with a plane of vibration perpendicular to a line to the wavelength light which becomes lambda>>d. That to which what drew the gold streak at intervals of d= 0.3 micrometers to the silver-bromide substrate drew the aluminium wire by d= 0.7 micrometers to the polyethylene plate as an object (16-100 micrometers) for far-infrared rays as an object (2.5-25 micrometers) for inside infrared rays is used. Moreover, there is a Poral core (trade name) by Corning, Inc. By making an one direction arrange the metal silver made to extend for a long time in [glass's] an own one, this is glass which gave the polarization property and, unlike the conventional organic substance polarizing element, is very excellent in thermal resistance, moisture resistance, resistance to chemicals, and the resistance over a laser beam. Moreover, there are some which are called a micro wire array, the front face of aluminum was made to anodize for infrared radiation, and used as the alumina, made the detailed hole, put metals, such as nickel and Cu, into inside, and were used as the polarizer. Furthermore, there are some which are called a laminating mold polarizer. This carries out the laminating of germanium with a thickness of 60-80A and SiO2 of 1-micrometer thickness by turns by the RF sputtering method to the lights, and the whole thickness is produced as 60 micrometers. The extinction ratio measured on about 400 and the wavelength of 0.8 micrometers is 35dB, an insertion loss is 0.18dB, and performance-index alpha TE/alpha TM (ratio of an extinction constant to a TE wave and a TM wave) measured on the wavelength of 0.6 micrometers is enough to the light.

[Translation done.]

EXAMPLE

[Example] Hereafter, the concrete example of a configuration based on the example of a configuration mentioned above is explained with the examples 1-5 of a comparison as examples 1 and 2.

[0025] the quartz substrate (transparence substrate 2) top of 1> 0.5mm thickness of < examples — the ion plating method — using — SiO2 (dielectric film 8a [of a low refractive index], refractive index n= 1.47) — 88.4nm and Ta 2O5 (dielectric film 8b [of a high refractive index], refractive index n2.15) — 60.5nm — it considered as thickness, and by turns, a total of 12-layer laminating was carried out, and it formed six layers of dielectric multilayers 3 at a time. the substrate temperature at this time — 300 degrees C and the oxygen-gas-pressure force — SiO2 the case of the film — the case of 2O1.0x10~4Torr and Ta5 film — 1.1x10~4Torr it was . Membrane formation Leto is SiO2. In the case of film, in the case of film [2O2 nm/s and Ta5], they were 0.5 nm/s. The differences between the place where thickness distribution of the dielectric multilayers 3 is the thickest, and a thin place were 3% of all thickness. Subsequently, on such dielectric multilayers 3, the sputtering method was used, and Bi permutation rare earth iron garnet film (transparence magnetic layer 4) was produced so that average thickness might be set to 520 / 2= 260nm. At this time, further, the baffle has been arranged in front of a quartz substrate, and the distance from right above [evaporation source] was adjusted, and membranes were formed so that thickness might change continuously **14% focusing on average thickness in 2mm angle. Substrate temperature was made into 400 degrees C at this time. Then, the film on this substrate was heated at 650 degrees C among air for 3 hours. The membranous presentation was Bi2.2Dy0.8Fe3.8aluminum 1.2O12. It was 19nm when asked for the full width at half maximum from the wavelength dependency of the faraday's rotation angle measured with the magneto-optical-effect measuring device (K250 by Jasco Corp., beam diameter angle of 2mm). On the wavelength of 520nm, the peak value of an angle of rotation was 2.2 degrees. The coercive force which impressed the field at right angles to a film surface, and measured it by VSM was 600Oe(s). Subsequently, it is SiO2 completely like the case of the dielectric multilayers 3 which used the ion plating method on such Bi permutation rare earth iron garnet film, and were mentioned above. The dielectric multilayers 5 of the film and 2OTa5 film were produced. The film which is directly in contact with Bi permutation rare earth iron garnet film is 2OTa5 film, and the maximum surface side is SiO2. It is the film. On the wavelength of 520nm, it becomes the 13.0-degree angle of rotation which becomes about 6 times to the above-mentioned 2.2 degrees from the wavelength dependency of a faraday's rotation angle.

[0026] Using such a process, on the quartz substrate, the structure which becomes 4/dielectric multilayers 5 of 3/transparence magnetic layers of dielectric multilayers was repeated twice, and it formed at multilayer structure. A 25.3-degree faraday's rotation angle is acquired on the wavelength of 520nm. Moreover, the angle-of-rotation full width at half maximum centering on the wavelength of 520nm was 78nm. It inserted with the film polarizer (polarizers 6 and 7) of the pair which is having the outermost layer of the above laminating structure marketed, and the alphabetic character was written with the magnetic pen to which the permanent magnet (surface-inductive-flux 3k gauss) was attached from on the film polarizer. Then, when the film polarizer of a pair is rotated slowly, the alphabetic character drawn with the magnetic pen is displayed (visualization). The contrast of the image part at this time was those with 4.4, and a legible display image.

[0027] Except the point which formed this transparence magnetic layer 4 so that thickness might become uniform by 130nm, without giving change to the thickness of the <example 1 of comparison> Bi permutation rare earth iron garnet film (transparence magnetic layer 4) The place which produced the imaging device like the case of an example 1 altogether (the differences in the place where thickness distribution of the transparence magnetic layer 4 is the thickest, and a thin place were 4% of all thickness), On the wavelength of 520nm, it becomes a 25.7-degree faraday's rotation angle, and the angle-of-rotation full width at half maximum is as narrow as 23nm. Moreover, it inserts with the film polarizer of a pair and the contrast of the alphabetic character displayed when an alphabetic character was similarly drawn with a magnetic pen stops at 2.9. Therefore, it turns out that it is effective to carry out increase and decrease of the thickness of the transparence magnetic layer 4 of change continuously like an example 1.

[0028] The dielectric multilayers 5 which the dielectric multilayers 3 formed on the <example 2 of comparison> quartz substrate make ten layers, and are formed on Bi permutation rare earth iron garnet film (transparence magnetic layer 4) as 15 layers When a imaging device is produced completely like the case of an example 1 except changing the layer structure of the dielectric multilayers 3 and 5, on the wavelength of 520nm, it becomes a 18.1-degree faraday's rotation angle, and the angle-of-rotation full width at half maximum becomes 48nm and straitness. Moreover, it inserts with the film polarizer of a pair and the contrast of the alphabetic character displayed when an alphabetic character was similarly drawn with a magnetic pen stops at 1.7. Therefore, the dielectric multilayers 3 and 5 are understood that completely forming identically is effective like an example 1.

[0029] Except the point which produced the <example 3 of comparison> Bi permutation rare earth iron garnet film (transparence magnetic layer 4) so that average thickness might be set to 500nm, when a imaging device is produced completely like the case of an example 1, on the wavelength of 520nm, it becomes a 14.9-degree faraday's rotation angle, and the angle-of-rotation full width at half maximum becomes narrow with 30nm. Moreover, it inserts with the film polarizer of a pair and the contrast of the alphabetic character displayed when an alphabetic character was similarly drawn with a magnetic pen stops at 2.0. Therefore, it turns out that it is effective to form the thickness of the transparence magnetic layer 4 in about 400nm or less like an example 1.

[0030] It is SiO2 completely like the case of an example 1 on the quartz substrate (transparence substrate 2) of 2> 0.5mm thickness of < examples. The dielectric multilayers 3 by the film (dielectric film 8a of a low refractive index) and Ta 2O5 (dielectric film 8b of a high refractive index) were formed. Subsequently, on the dielectric multilayers 3, the

vacuum deposition method was used, and the iron ultrafine particle film (transparence magnetic layer 4) was produced so that average thickness might be set to 200nm. At this time, the metal mesh of 1mm spacing was arranged in front of the quartz substrate, and spacing of a mesh and a substrate was adjusted and membranes were formed so that thickness might change continuously **16% focusing on average thickness in 3mm angle. Substrate temperature was made into ordinary temperature at this time. a membranous presentation — iron 39.1atmic% and oxygen 36.6atmic% and carbon 24.0atmic% it was . The wavelength dependency of this faraday's rotation angle when measuring with a magneto-optical-effect measuring device is shown in <u>drawing 4</u> . On the wavelength of 550nm, it was a 1.6-degree faraday's rotation angle. Spectral transmittance with a wavelength of 550nm was 39.0%. Moreover, the coercive force which impressed the field at right angles to a film surface, and measured it by VSM was 320Oe(s). Subsequently, it is SiO2 completely like the case of the dielectric multilayers 3 which used the ion plating method on such iron ultrafine particle film, and were mentioned above. The dielectric multilayers 5 of the film and 2OTa5 film were produced. On the wavelength of 550nm, it becomes a 15.7-degree angle of rotation from the wavelength dependency of a faraday's rotation angle to the above-mentioned 1.6 degrees.

[0031] Using such a process, on the quartz substrate, the structure which becomes 4/dielectric multilayers 5 of 3/transparence magnetic layers of dielectric multilayers was repeated twice, and it formed at multilayer structure. A 26.4-degree faraday's rotation angle is acquired on the wavelength of 550nm. Moreover, the angle-of-rotation full width at half maximum centering on the wavelength of 550nm was 58nm. It inserted with the film polarizer of the pair which is having the outermost layer of the above laminating structure marketed, and the alphabetic character was written with the magnetic pen to which the permanent magnet was attached from on the film polarizer. Then, when the film polarizer of a pair is rotated slowly, the alphabetic character drawn with the magnetic pen is displayed. The contrast of the image part at this time was those with 3.3, and a legible display image.

[0032] When a imaging device is produced like the case of an example 2 except [all] the point which formed this iron ultrafine particle film so that thickness might become uniform by 200nm, without giving change to the thickness of the <example 4 of comparison> iron ultrafine particle film (transparence magnetic layer 4), on the wavelength of 550nm, it becomes a 16.0-degree faraday's rotation angle, and the angle-of-rotation full width at half maximum is as narrow as 28nm. Moreover, it inserts with the film polarizer of a pair and the contrast of the alphabetic character displayed when an alphabetic character was similarly drawn with a magnetic pen stops at 1.7. Therefore, it turns out that it is effective to carry out increase and decrease of the thickness of the iron ultrafine particle film (transparence magnetic layer 4) of change continuously like an example 2.

[0033] When a imaging device is produced completely like the case of an example 2 except the point which did not repeat the laminating of the structure of the 4/dielectric multilayers 5 of 3/transparence magnetic layers of dielectric multilayers formed on the <example 5 of comparison> quartz substrate, but was made only into 1 time, on the wavelength of 550nm, it becomes a 7.1-degree faraday's rotation angle, and the angle-of-rotation full width at half maximum is set a little to 45nm to slight straitness. Moreover, the contrast of the alphabetic character displayed when it inserted with the film polarizer of a pair and an alphabetic character was similarly drawn with a magnetic pen was 1.7. Therefore, if two or more layer loop of the structure of the 4/dielectric multilayers 5 of 3/transparence magnetic layers of dielectric multilayers is carried out and it is formed like an example 2, it turns out that it is much more effective.
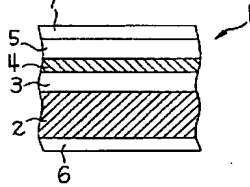
[Translation done.]

* NOTICES *

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the sectional view showing the theoretic configuration of the imaging device of the gestalt of 1 operation of this invention.
[Drawing 2] It is the sectional view showing its dielectric multilayers / transparence magnetic layer / dielectric multilayers structure.
[Drawing 3] It is the property Fig. showing the wavelength dependency of the faraday's rotation angle of a rare earth iron garnet.
[Drawing 4] It is the property Fig. showing the wavelength dependency of the faraday's rotation angle of an iron ultrafine particle thin film.
[Description of Notations]
3 Five Dielectric multilayers
4 Transparence Magnetic Layer
6.7 Polarizer
8a, 8b Dielectric film

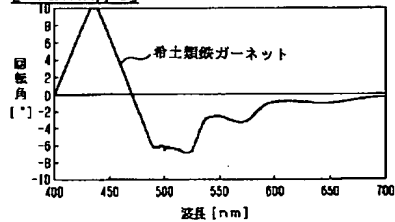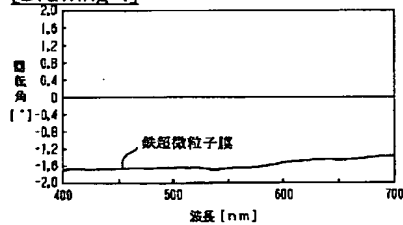[Translation done.]

* NOTICES *

DRAWINGS

[Drawing 1]

[Drawing 2]
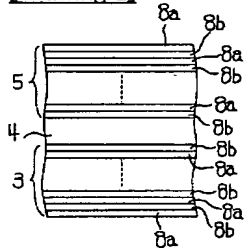
[Drawing 3]

[Drawing 4]

[Translation done.]